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ABSTRACT

Rural schools may have an advantage over urban schools in science teaching if sciences are perceived as means of exploring our surroundings, are presented as many viewpoints of one overall picture, and are taught in a form that deals with human situations. Collaboratively taught, rural science curricula can include study of agricultural ecology, rural biology, rural science, rural studies, world food supplies, the energy crisis, and solar energy. Taken as a whole, these courses illustrate an expanded approach to teaching about food production and the life and work of the countryside in general. Such an interdisciplinary approach gives the science teacher the opportunity to help meet some of the educational needs of young people by providing practice in enquiry; calculation and measurement; design; communication; values; and in organizing information, making decisions, and thinking critically. For such a curriculum to be successful, rural science teachers need training and continued financial and resource support as well as flexibility in scheduling. Specific topics are included for each course suggested. (SB)

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# THE SCIENCE PROGRAM in SMALL RURAL SECONDARY SCHOOLS

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# THE SCIENCE PROGRAM IN SMALL RURAL SECONDARY SCHOOLS

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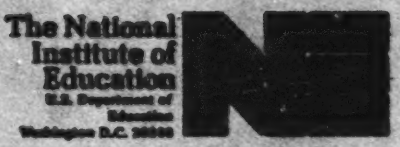


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## INTRODUCTION

It is usually assumed that education in general, and science courses in particular, must be inferior in the small rural high school because of its limited resources, both human and material. This might be true if there were indeed "one best way" of teaching and if this were the one used in the large urban school, for then it, with its larger numbers of subject specialists and specialist rooms and its much greater complement of scientific apparatus, would seem to be better off. But there is no one best way, and that which is generally practiced is far from satisfactory, to judge by the National Science Foundation surveys quoted later. If science is learning facts from a book and carrying out more or less complicated "experiments" to demonstrate something that is already well known to the teacher, and perhaps to the students, if science is always a distillation of reality and never the real thing itself, and if scientific disciplines are specialized, distinct areas of knowledge unallied and unalloyed with the other subject areas, then the rural school truly is at a serious disadvantage. If teaching is a mass production affair, mainly concerned with those who will go on to higher education while the rest must accept a watered-down version of the same diet, then again the rural school cannot compete with its urban counterpart.

If, on the other hand, we look upon science as an exploration of our surroundings, as a method of finding out about things, and as something that, through the medium of technology, has a profound effect on all our lives, then the rural school is at an advantage. For the rural environment is an open book where plants and animals, rocks and soil, sun, wind and

rain are available for study and where human use of these natural resources is also evident. In the city, weather is simply pleasant or unpleasant, comfortable or uncomfortable, whereas to the country worker it has a profound effect on life and livelihood. Soil usually receives scant attention in biology and earth science courses and is just "dirt" to the average townsman, but in the countryside it is seen for what it is: the basis of our food supply, the raw material of a great industry—to be battled or coaxed, conserved or exploited, to serve human ends. Living things are there, to be enjoyed for their own sakes or to be studied as resources for mankind or as enemies to be controlled. Against this background, human settlements and occupations have grown in a way that usually shows their clear relationship with the environment and its resources. Thus, natural sciences, social sciences, and technology can be studied as viewpoints of one overall picture and not as isolated disciplines. The scale is such that study and intervention take on manageable proportions, and the closeness to the social and natural environments gives point and relevance to learning.

Much of our environment, particularly in urban areas, is the product of technology that is remote from everyday experience and probably must remain so. Food, however, is now the product of a high technology; yet it is one that is accessible to most, though admittedly not all, rural schools. Furthermore, in spite of the town dweller's view of the country man as unlearned, there are few industries in which the latest scientific discoveries are put into practice more quickly than agriculture. Farms and the countryside in general are a richly endowed laboratory in which observation and experiment can be carried out with a minimum of equipment and parts, many of which can be reproduced in miniature on the school

grounds. An investigation of the wheat crop, for example, could lead to studies of plant physiology, of soil and its management, of the effects of climate, and of genetics and the evolution of modern wheat. Linked to these studies would be an examination of the Green Revolution and its potential effects on world food supplies, study of weeds, pests, and diseases and methods of combatting them, review of the economics and politics involved in the production and trade of grain, and investigation into the energetics of crop production and the mechanics involved in farm machinery. Underlying these would be the necessary understanding of the physics of climate, of energy transformations in food chains and farm machinery, and of soil structure, as well as knowledge of the elementary chemistry of soils and fertilizers and of the geology of soils and landforms, and so on. So, in farming as in other aspects of the rural scene, the rural school has resources which, if used effectively, will largely compensate for other deficiencies.

The needs of the college-bound students tend to dominate the curriculum, often to the detriment of other students. The usual system might be likened to a stalactite in which the top comes first—the top in this case being the college-bound students—with everything below depending on their needs. Once the college-bound have been catered to, then the rest tag along as best they can, often being offered some watered-down version of "college-prep" courses. However, stalactites tend to be rather brittle. Perhaps we should aim at the stalagmite—a more robust structure which grows upward from below—as our model. As homemakers, as ordinary citizens, and as community members, we all need to function on a similar level. To this extent, we make our way in the same world, and we need

the same preparation for it. From this common basis, special needs arise, mainly preparations for work. Predominant among these vocational needs are those of the college-bound, for preparation for college is vocational education, though of a rather less specialized kind than, say, business training. The specialized needs of such groups should be an extension upwards from the foundations of education. Provisions for them constitute additions that extend the more academically able, as a stalagmite grows up from its broad base.

Small numbers of students may not justify the teaching of specialized courses of the standard type, especially if these demand a quantity of specialized equipment. However, such small classes offer the incomparable advantage of allowing young people to be treated as individuals, not as items in a mass production system. In spite of what some researchers have told us, teaching in smaller classes, even in traditional classrooms, is more effective than in larger classes, as every teacher already knows. If class sizes are so low that they do not appear to justify staff time, then alternative timetabling arrangements, individual projects, etc. can be used to help meet the needs of the few.

The lack of specialists in each of the separate scientific disciplines—biology, chemistry, earth sciences, and physics—is a grave disadvantage if these separate disciplines are required and if specialists in only one or two are available. If, however, interdisciplinary science courses based on themes such as the energy crisis, dealt with more fully later, are taught, then one or two teachers with sufficiently broad training can cope, especially if they are free to design courses based on familiar, local situations and resources.

Until such time as more teachers, specifically trained with the rural schools in mind, are available, outside resources will have to be made available to support rural teachers who wish to change their style of teaching. Teachers' associations made up of like-minded science teachers can help by providing mutual support. Perhaps if rural science teachers could find this support from their specialist colleagues living and teaching within a reasonable distance and if, together, they could design science programs particularly suited to their schools and communities, they would find their jobs a little more congenial and professionally satisfying and they might be less anxious to move on to "something better."

Whatever changes are made to accommodate the science program to local needs in a rural community, they must be consistent with good science and good education. Science teaching must play its part in developing those skills and attributes which we expect to find in an educated person; and, however locally based the pathway to learning may be, it must lead the student to an understanding of the basic concepts, the "big truths" of science. Teaching based on the familiar experience of the student is more likely to achieve this goal than is teaching by the traditional approach.

The small rural high school has advantages which are envied by both teachers and students in larger institutions: small class size and small faculty numbers with consequent familiarity and ease of getting together for planning meetings. These allow relatively uncomplicated schedules which allow for flexibility in the use of time for both teachers and students.

The weaknesses of the rural school are weaknesses only if that rural school plays in the "wrong league" alongside the large urban school. In that situation, it will always be second best in terms of number and

variety of courses, specialists to teach them, and facilities available. Building on its own strengths, however--the closeness of the community, the educational opportunities of its environment, its family atmosphere, the relative simplicity of its timetable and its constant flexibility--the rural school can offer an education which is different from that of the urban school but which is appropriate to the needs of its students and which is in no way inferior to that offered in larger schools.

In looking at what might be done to improve the science curriculum in small rural schools, it is necessary to consider briefly what the aims of education are, what part science teaching can play in meeting these aims, what special attributes the rural environment has to offer as a resource for teaching, and how schools can be helped to bring about change where this seems desirable.

The following pages present possible answers to these questions:

1. Why change? What is wrong with what we are doing now?

2. Why do we teach science? From the student's point of view, "What does it mean to me?"

3. What part can science teaching play in developing those attributes that we expect to find in an educated person?

4. Should the small rural school offer a program different from that of the large urban school? To what extent are special needs and interests compatible with and to what extent are they different from nationwide needs and aspirations in education?

5. Contingent upon the previous questions, can the fundamental concepts of science be taught effectively through a rurally oriented science curriculum?

7. What contributions can new programs make to the community as a whole?

## SOME EDUCATIONAL NEEDS OF YOUNG PEOPLE: "INTERMEDIATE SKILLS"

### Enquiry

Information is a necessary prelude to action, but packages of textbook facts are not always the best kind of information, especially in a world where the facts change so rapidly. "We spend our time in schools packing for journeys we never undertake," as one educator put it. What is needed is not so much the memorizing of information as exercise in the ability to find out, to have some idea where to look, and to discover what techniques are available. The library is an obvious source and one with which most students have more than enough practice, but students also need practice in searching out information in a variety of other ways: by conducting scientific experiments; by interviewing experts or community members; by observing and recording, as in a crop survey; by submitting questionnaires to a sample population; by sending letters of enquiry; by visiting or otherwise contacting official bodies; and so on. For example, a survey of the local community and surrounding countryside, carried out as an interdisciplinary class or group project, could involve students in all these ways of collecting information.

### Calculation and Measurement

Simple calculation and measurement are part of everyday life: we measure the windows for new drapes, the walls for new shelves; we balance the checking account; we estimate how much gasoline we will use

on a vacation journey; in the garden, we need to work out the area of land available for each crop, the amount of fertilizer needed, the length of rows, the amount of seed needed, the weight of potential crop, and so on. However, many people are unable to estimate; they cannot give the rough and ready answer which ought to be a preliminary to more precise computation. Without some idea what the answer ought to be, the now almost ubiquitous calculator can be dangerously misleading, for it is so easy to touch the wrong button and get some wrong answer which a little common sense and simple mental arithmetic would expose. We do not give students enough practice in common-sense estimation and in "thinking with numbers." Science teaching is as much at fault as mathematics teaching here for the emphasis so often lies in precision of measurement and accuracy of calculation as the supreme attributes of the scientist. True enough, the almost unbelievably precise measurements made by modern science, encompassing dimensions from the unutterably small to the incomprehensibly large, are among the supreme human achievements. However, scientists at work, thinking, are often more interested in the rough estimation—the "ball park figure"--than in the exact number. As modern computing aids become more commonplace, the need for computational skills declines, but the need for the ability to reach some rough conclusions, to have some idea of orders of magnitude, increases.

Communication

The effective use of language, both written and oral, is clearly essential. That is, people need to pass on what they have to say clearly and unambiguously, in logical sequence, as concisely as suits the situation, and as simply as will allow the necessary precision. Confused speech and muddled writing are frequently a sign of muddled thinking; therefore,

language well used is both an indication of, and an aid to, clear thinking. Although our scientists often set a deplorable example in their research reports, developing the precise use of language should be one attribute of our science teaching.

Mathematics is another type of communication. We teach a great deal about computation in our math classes; yet most people are unsure of themselves when it comes to using mathematics as a tool, as a means of solving everyday problems, and as a means of communication which adds precision to the use of language. We say that this product is better than that; and, if called upon, we can enlarge upon and define more closely what we mean by "better"—it is thicker, heavier, more resistant, less expensive, and so on. But how much thicker, how much heavier is it? How much longer does it last under certain conditions? How much cheaper is it? To answer these questions is to describe the product with a higher level of precision; yet so many people do not use mathematics as a language in this way or as a tool in making decisions in everyday situations. Practical scientific investigation will almost inevitably encourage the more effective use of numbers and measurements.

Communication nowadays is increasingly a matter of charts, tables, maps, graphs, samples, surveys, and statistical probabilities. We are told that this product is so much percent better than that, that such and such a politician leads another by so many percentage points in a sample of so many thousand, and that the figures are reliable within certain limits. There is a 40% chance of rain tomorrow, and we are shown all sorts of maps and diagrams in the weather forecast to illustrate why this is so. Quite often this information is fed to us by politicians and commercial advertisers

to persuade us to take this or that course, but often the displays are unclear, ambiguous, or deliberately misleading. So we all need to know how to read charts, graphs, diagrams, and other visual presentations as well as textual matter critically and with the ability to discriminate between what may be suggested and what is actually said. Conversely, we need to present our own points of view honestly but forcefully and persuasively.

Organizing Information and Making Decisions

Information, once collected, needs to be sorted and organized in some form to be useful as the basis for making personal decisions, as material for public display, or as a permanent record or source of reference. One source of information we are frequently called upon to evaluate is the persuader, be he advertiser offering some product or service or politician selling himself and his policies. What exactly does the persuader say? "More people buy brand X." So what! Perhaps they have poor taste! "Many professional cooks recommend...." How many is "many"? "Such and such lasts longer." How long is longer? Do the figures ring true? Is there any way of checking them? Do charts and graphs present information in an unbiased way? There is no easier way of distorting facts than by a graph with no figures, an exponential curve on a logarithmic scale, a diagram in which linear increases are represented by areas so that something that is twice as big is represented by, say, a square of twice the size, so that the actual area is four times as big.

Students need an opportunity to collect information from original sources and to assess alternative viewpoints. Too often we feed them predigested textbook information which robs them of the opportunity to weigh opposing arguments. In the many ways in which information is collected,

organized and evaluated, science teaching should play its part for the critical, skeptical attitude of the scientist is perhaps the citizen's best protection against those who are prepared to tell the truth in subtle ways.

Design

Design may seem rather a strange category alongside the others, but it embodies something with which we are all concerned in one way or another. We decorate our homes, decide on our dress, plan our gardens, arrange vases of flowers, and choose furniture, ornaments, and fittings, and do a host of other things. We express our creativity and that indefinable attribute, our good taste, in a multitude of ways. But design, in the sense intended here, is more than aesthetics. It embodies fitness for purpose, functional efficiency, appropriate choice of materials, and their effective use. Beyond all this it demands knowledge. To design a solar collector one needs a scientific knowledge of the behavior of materials to be used; light transmission, reflection, and absorption; conduction; insulation; and the incident solar radiation. Further, one needs the technical knowledge to construct the apparatus of appropriate materials; one needs to know strengths and durabilities of these materials and the techniques needed to assemble them. One needs also the aesthetic vision to see that the finished product is pleasing in appearance, well made, and functionally effective. It is in this sense that we are all more or less involved with design, whether it is something as new and complex as constructing a solar collector or as familiar and simple as icing a cake or making a skirt. Design is certainly a great deal more than putting paint on paper. Usually it will involve aesthetic judgment and technical skill, but when scientific design and careful calculation can be added, as in the example of the solar collector, it

is to be welcomed as a way of bringing science into everyday situations.

Values

Young people expect their elders to have values and to be prepared to stand up for them. They don't necessarily want to be led, certainly not coerced, but they do need standards against which they can judge their own opinions. From a scientist they can expect reliable facts, or the means to get at them, some guidance as to possible consequences, acquaintance with balancing opinions, and objective assessment before subjective comment.

Now science teaching has no monopoly in teaching these skills, but it has the potential for making a significant contribution to all of them. Beyond this it can make an important contribution to the teaching of "the 3 R's." If students are engaged in investigations that are interesting and stimulating, they want to communicate their findings and they want to find out what other people have learned in the same areas. They will read because they need to, and they will tell other people about their work—certainly by talking, perhaps by writing and by preparing graphs, pictures, diagrams, or other appropriate forms of communication. For an audience that is not immediately present, written language will almost certainly be needed, but it is characteristic of science that statements must be made as accurate as possible. This means that not only must language be used with precision but also that measurement and calculation will enter into the description. In this way, science teaching will contribute not only to the development of the students' ability in the intermediate skills but in the basics as well.

A local survey, which might be updated from year to year after the initial survey is completed, would be one way of engaging students in work that combines all of the basic and intermediate skills, and science

and mathematics would be important components. Various modes of enquiry would be needed: observation and mapping in a land utilization survey; experiments, perhaps in recording solar energy and determining what contribution it could make to the community energy budget; social survey techniques to find out where people go for shopping or other amenities or to find out how much energy—electricity, gasoline, wood, etc.—is imported into the community; interviews to find out about local history; enquiries of local, state, and federal agencies to find out sources of advice, regulations, and so on.

Having been collected, the information would have to be sorted, evaluated and organized in some logical manner. Several courses might then follow. Perhaps an exhibition would be arranged for the rest of the school, but since this would be of interest to the community as a whole, a public exhibition might be held. A local guidebook might be another outcome while the collection of material should be maintained in some small "local records office," which in turn might lead to some sort of local citizens' advice center. The presentation of the information, then, would require a wide range of methods of communication—written reports, oral presentations, visual displays, statistical summaries, graphs, maps, and so on.

The effective presentation of the material would be a fine exercise in design, but a study such as this should be concerned not only with what was and is but also with what might be. How could the community be improved, how could change be accommodated—an influx of new people or new industries, for example—so that planning for the future could be incorporated into the design of physical improvements? Thus, young people would have to examine their own and other people's values in deciding what

changes are desirable and what accommodation should be made for differing needs and interests.

All of this suggests not only that the science teacher has a part to play in many aspects of academic life not usually looked on as "science" but also that some form of interdisciplinary study, of collaborative teaching, is almost a necessity for preparing young people for their varied roles in the community.

## LOCAL INTEREST AND LIBERAL EDUCATION

A major problem in developing a curriculum for any special group is to determine to what extent the special needs are to predominate and to what extent general educational principles are to apply. Minority communities rightly demand an education which takes into account their cultural situation. Yet we are all citizens of the same country. Special vocational groups such as teachers or engineers need an education suited to their particular needs; yet as private individuals they are much like the rest of us. Similarly, students growing up in rural communities need an education that is meaningful to them in their environment; yet they share many problems with students in city schools. In a society as socially and geographically mobile as ours, our education must prepare us to function as citizens in the common culture: we vote about issues of war and peace and on public policy which regulates our nation; our mass media cater to nationwide audiences; and we are part of one society sharing a common heritage. We are realizing more and more that we, along with all other people, are voyagers on the spaceship earth. So the problems of that spaceship, its diminishing resources, its pollution, and so on, affect us all directly or indirectly. Yet

at the same time we want to feel that our education will enable us to come to grips with the particular environment in which we live at the time.

Though students in rural communities live in an environment far removed from that of the urban or suburban dwellers, they share the same heritage of human achievement: the music of Beethoven, the sublime language of Shakespeare, the artistry of Michelangelo. The laws of nature apply equally in town and country, in northern city and mountain ranch or fishing village. The same sun shines on a Navajo village, a black ghetto, and a wealthy suburb; and educated persons in any of these situations might be expected to have much the same understanding of the means of communication, of the laws of nature, and of the use of figures, for example.

A schooling designed to produce an educated person in one situation ought to suit in any other. But, of course, life as it is lived in these diverse communities is not the same. This is as true of science teaching as of anything else. One of our problems is to decide to what extent universal truths, the "big ideas of science," shall occupy the curriculum and to what extent local conditions, problems, and interests are to dominate. A curriculum determined by the former is likely to seem to rural children to be of little consequence to their lives and conditions. On the other hand, one determined purely by immediate local interests and vocational needs is likely to be superficial and shallow.

One of the challenges of a new and revised rural science curriculum, therefore, is to use the local environment as a medium through which to uncover underlying scientific truths. It must involve students in matters of clear importance to them and the community. It must explain what is going on in their surroundings; yet at the same time it must inculcate in the students

something of the spirit of science and provide them with a sound grasp of some of the important scientific concepts, some of the universals.

## TOWARDS A SCIENCE FOR RURAL SCHOOLS

The following suggestions, all of which have been well tried in one setting or another, incorporate one or more of the principles outlined in the previous sections. They all illustrate science in a less esoteric form than is common because they deal with human situations and man's use of the land on the one hand and with the present energy situation on the other. They are examples of the sort of thing that might be done, not prescriptions for what should be done. In no instance is it suggested that they are even outlines of a proposed syllabus; they merely indicate lines of approach.

The first five suggestions illustrate an expanding approach to food production and the life and work of the countryside in general. The proposals move from a narrowly ecological approach in farm ecology, through a more general biology based on crops and livestock husbandry, to an interdisciplinary "rural science," and then to an even more broadly interdisciplinary approach in "rural studies," and finally to a world-encompassing view of food production which, though based on the principles and practices of agricultural production, of necessity incorporates aspects of politics, economics, sociology, and history and which indeed might be an integrating theme for a curriculum-wide study. The core of all these approaches is the study of agricultural production.

At all levels of education, agriculture seems to be treated as a vocational subject--something that concerns only future farmers--but it is arguable that a study of food production should be considered an essential

part of a liberal education. It is the world's greatest industry. In fact, agriculture is the foundation of a settled, civilized way of life that has made possible the grand range of human achievements, and it is necessary to satisfy our daily needs. Since the proportion of the population employed in agriculture has shrunk to some 4% and is still shrinking, it has been suggested that vocational agriculture is now an unnecessary luxury, especially in areas of family farming, where it is claimed children can drive a tractor almost as soon as they can walk. Perhaps the expertise and facilities available for vocational agriculture might be better employed in giving all students some feeling for and practical experience in the care of plants and animals for human ends. If our land is to be used wisely and agriculture is to thrive, it is not sufficient that the farm community understand its importance, as of course they will. Politicians and bankers, businessmen and planners, and in fact the whole of society, must realize the importance of a healthy agricultural industry. These outsiders in the aggregate are likely to affect agriculture as much as those within the industry.

The opportunities for realistic practical work that abound in these studies are of primary importance. Much of the laboratory work in biology involves the handling of dead specimens, but here is the opportunity to care for and observe living organisms—organisms which are maintained to contribute to human welfare. Here science can be seen, not in a stereotype form enclosed in a laboratory full of glassware and chemical bottles, but literally in the field. Students will be tackling practical problems. While experiments with animals must be limited to those that one can be sure involve no cruelty, the possibilities for experiments with crop plants and their environment abound.

Agricultural Ecology

We live at a time when ecology is a real issue. Now we realize that "everything is connected to everything else" and that a more comprehensive, holistic view of nature and our place in it is needed if we are to understand and moderate our impact on our surroundings and to use the finite resources of the earth wisely and to the best long-term advantage. Most courses and textbooks on ecology concentrate on natural systems—the ecology of grasslands, forests, seashores, etc. Often these are not easily accessible for practical study, are fragile, or in some other way are not of immediate relevance to the lives of the students. But the subject matter and resources for ecological study of the man-managed ecosystems lie all around us in farms, gardens, parks, and anywhere else that man closely manages the lives of plants and animals.

The idea of energy flow through food chains and webs is central in ecology. What is more important than to apply this to the human food supply as exemplified in local farms and gardens? How efficient is this or that crop in converting solar energy into human food? How many calories per acre do local crops produce and what does this amount to in terms of human sustenance? What is the efficiency of converting this food into meat, eggs, or milk and what implications has this in terms of the price of food and of feeding a steadily growing world population? What are the losses: the energy drain caused by weeds, pests, and diseases? How are they combatted and at what cost in mechanical and chemical energy and in terms of cash expenditure? How effective are our short- and long-term efforts and at what environmental cost? What are the other energy inputs in cultivation, fertilizing, harvesting, storage, transport, processing, packaging, marketing, and cooking in the home? How does this affect the price to the consumer?

All the aspects of elementary ecology are similarly amenable to treatment using agriculture and horticulture. Population dynamics is involved in dealing with planting distances in crops, rates of stocking of grazing animals, build-up of pest populations, and so on. In the study of soils and their management and of climate and the use of artificial climates in such places as greenhouses and poultry houses, we see the interaction of biotic and abiotic systems and the steps taken to modify them to achieve maximum productivity for human ends.

One of the attractive features of this approach to ecology, apart from its obvious importance to all of us, is that since these humanized ecosystems are as simplified as the farmer can make them--ideally, from the present viewpoint they would consist of only one species--they are relatively easy to study both theoretically and practically. Apart from other considerations, the sheer problems of identification which are so time-consuming and frustrating in natural systems are greatly simplified. Such ecosystems can be created on the school grounds, on a very small scale if necessary, are available for study, and can be interfered with and altered at will without any of the restraints that one might feel called upon to accept in dealing with natural systems. The importance of studying the population density of a competing species and the results of its removal is quite obvious in the case of weeds in an onion patch; however, it is not so clear in an alpine meadow. Furthermore, a school greenhouse enables these studies to be carried on in comfort throughout the winter when in many areas outdoor work is impossible or at least downright uncomfortable.

Topics dealt with in a rural ecology course might include the following:

1. Energy flows. Food chains and webs in production systems; the farm as a managed ecosystem; simplified ecosystems in crop production; crop efficiency—gross and net primary production; energy subsidies in the form of cultivation, fertilizers, etc.; pest and disease organisms as energy drains; the grazing food chain—food conversion efficiency in animal production, its implication in the food system; the decomposer food chain—its importance in soil fertility, energy flows, and nutrient recycling.

2. Abiotic/biotic interactions: the Cycles of Matter. The carbon cycle; effect of burning fossil fuels on atmospheric carbon dioxide and possible climatic change; carbon dioxide enrichment in greenhouses; the hydrological cycle; balance between evaptranspiration and precipitation; the nitrogen cycle; biological nitrogen fixation and the use of artificial fertilizers; the phosphorus cycle.

3. Climatic Factors in Production. Variation in yields due to climatic factors—the Dust Bowl; temperature and plant growth; solar radiation and day length; the concept of the growing season; precipitation and irrigation—artificial rain making and the problems it poses; long-term climatic change and possible effects of human activities on climate; artificial climates in production; greenhouses; poultry and pig housing.

4. Soil Factors. Soils—formation and fertility; chemical and physical properties—drainage, water retention, PH, humus content; loss of soil through erosion under various crop regimes; soil conservation; fertilizers and fertilizer use; artificial composts; hydroponics and aggregate culture.

5. Biotic Factors. Population and population interactions; predator/prey and host/parasite relations; symbiosis, carrying capacity,

stocking rates, and effects of overgrazing; population densities in crops; population build-up and decline in pest populations; exponential growth; damage caused by weeds, pests, and diseases; chemical control and its drawbacks; biological control.

Rural Biology

It is surprising, or it should be when one stops to think about it, how little attention is paid in the average biology textbook and average biology class to all those plants and animals on which human existence depends and to man's efforts to manage and improve them for his own advantage. Yet cabbages and wheat, cows and chickens matter a great deal to us and in the fields or on the plate are much more familiar than the usual run of biological specimens, which are not of pressing importance to most of us. Some elementary study of the inheritance of round and wrinkled peas is commonplace, but rarely do we find elementary biology courses in which the use of genetic knowledge has led to cheaper eggs in winter, more wheat and rice for hungry people, or more attractive petunias for the front yard. Yet in our gardens and on our farms we can see evolution at work in a time scale short enough to be understood, even if the slow progress of evolution by natural selection through the ages seems remote and unreal.

Most of what is to be taught in an elementary biology course can be dealt with using the plants and animals of farm and garden instead of the textbook diagram or the pickled specimen, and perhaps there is as much to be learned in caring for and understanding a live animal as in cutting up a dead one!

Among the advantages of a rural or farming biology course are the following:

1. The materials are generally abundant and easy to come by.

2. Practical experiments and observations are relatively easy to arrange.

3. Especially with a greenhouse, materials are available year round.

4. Experiments can be realistic. They are not textbook exercises translated into "3D," but genuine investigations which do not have known results and which could conceivably have new practical applications.

Perhaps the overall framework of a rural biology course would be much the same as that of a standard course, but it would use different examples and vary the emphasis put on certain topics. For example, stem structure in woody dicotyledons and the function of the cambium layer in secondary thickening are frequently covered, but not their importance in grafting fruit and nut trees and ornamentals. The production of adventitious roots is scarcely touched upon although in propagation by cuttings it also is of first importance. Our knowledge of growth controlling factors such as photoperiodic induction and growth hormones and giberellins is a fascinating topic which offers wide scope for experimentation.

Other topics worthy of special attention are the following:

1. Bacteria, fungi, and viruses as pathogens.

2. Symbiotic and saprophytic fungi and bacteria.

3. Silage making, alcoholic fermentation for beverages and fuel, methane production.

4. Nematodes as agents of plant disease.

5. Systematics of crop plants. The two largest plant families, the Orchidaceae and the Compositae, provide us with remarkably few crops--

vanilla in the former case and relatively few such as lettuce, sunflowers, and artichokes in the latter. In contrast, where would we be without the Graminae which provide the cereals and pasture grasses as well as sugar and bamboo, or the Leguminosae which give us the many kinds of beans and peas as well as such important forages as clover and alfalfa.

6. Evolution through selection and hybridizing of crop plants and animals.

7. The development of new strains of pathogens and of insecticide resistance in insect pests.

8. Breeding for special purposes such as disease resistance, improved amino acid content in high-lysine corn, increased fertilizer response and wide climate adaptability in Green Revolution cereals, suitability for mechanization as in monogerm sugar beets, quick-maturing broiler chickens with high food conversion, high twinning in sheep, etc.

Naturally enough, an understanding of the morphology, anatomy, and physiology of crop plants and farm animals is as important in farm biology as in general biology, while perhaps more attention can be given to environmental factors such as soil and climate and both intraspecific competition and attacks of pests and diseases of crops and stock. This leads naturally to ecological studies such as those mentioned under agricultural ecology.

All too often, plants are studied in isolation, removed from their environment of soil and air; but, as crops, they must be looked at in relation to soil conditions and the effects of the weather. Their relation to other organisms is often all too clear in the results of the attacks of pest and disease organisms, the competition of weeds or overcrowding of their own kind.

Rural Science

A broadly based interdisciplinary science, in which the subject matter of a rural biology as outlined in the previous sections is augmented by relevant topics in the physical and earth sciences, would form a rural science syllabus. Such a course might cover, in addition to purely biological subjects, the following areas:

1. Soils and Topography. The natural vegetation and the crops that can be profitably made to replace it are dependent on the nature of the soil and the landforms upon which it rests. Underlying geology and processes of erosion and soil formation are basic to a study of the rural use of land, including the nature of soils, the maintenance of fertility, the uses of fertilizers and manure.

2. Climate. Irrigation and water supply for farm, domestic, and industrial purposes would be included. Export of water to other regions (or perhaps its import in some areas); the effects of climate on natural vegetation, on the type of crops that can be grown, and on the variation in yields caused by climate fluctuations, as well as the principles of weather forecasting, would be among the subtopics.

3. Substructures. Principles of structural mechanics, heating, lighting, and incubation in such structures as laying battery houses and pigsties would be studied.

4. Electricity. Generation and distribution to rural areas; small-scale generation using windmills, etc.; uses of electricity in heating and lighting farm buildings and other structures; electric motors; control devices—thermostats, relays, photo-sensitive devices, timers, etc.—all are important to the study of rural science.

5. Farm Machinery. The internal combustion engine, including the basic mechanics of farm implements and the energy they consume, adds another dimension to the study.

6. Energy. Energy sources in the rural scene: replacing fossil fuels by local energy resources such as wind, water, biomass—gasohol, methane, solar energy; the energy involved in various primary production activities; increasing mechanization of agriculture and the resultant increasing energy demands and reduction of the labor force; the ratio of calories input/output in various farming enterprises; the energy used in other parts of the food industry—transport, processing, etc. --have become of critical importance.

## Rural Studies

The majority of rural secondary schools in Britain offer courses in a subject known as "Rural Studies." As emphasized in the previous sections of this paper, these courses too are based on the study of the plants and animals useful to man. They originated in school gardening, taught as a practical craft. In some cases, rural studies have not gone far beyond that stage but quite often they have branched out to incorporate studies of social and economic aspects of life and work in the countryside, wildlife, ornamental gardening, and floral decoration. Often there is close collaboration with the domestic science staff to allow students to see the whole process from sowing seeds or hatching eggs to a finished meal. More recently, as concern about our treatment of the environment has developed, rural studies have become the foundation of environmental education in many schools.

Rural studies teachers have been hard put to find a satisfactory definition of such a multifaceted subject, and many indeed insist that it

should not be looked upon as a separate subject at all but rather as a mode of approach to the curriculum that operates as a general theme. Be that as it may, most school programs are built on a subject basis, and an association of teachers of rural studies defined rural studies as study of the following areas:

1. The landscape--its topography, geology, pedology, and climate.

2. The ecological relationships of the plants and animals naturally present.

3. The use of the natural environment through agriculture, horticulture, forestry, and other forms of land management.

4. The development of an appreciation and awareness of the natural surroundings.

This rather stark and terse statement does scant justice to the richness and diversity of the educational opportunities inherent in the study of the countryside. A paper read by the writer at a conference on Environmental Education at the University of Leicester in 1970 had this to say about rural studies:

> [Students ought to know about] the basic ecological relationships between organisms and their environment. That life depends on energy from sunshine trapped by green plants. That the soil is involved and the atmosphere. That there is a flow of energy through ecosystems and a cycling of chemicals of which oxygen, carbon and nitrogen are particularly important.
>
> That man is a part of the world complex of ecosystems. That in simple societies like our pre-agricultural ancestors or the simplest of present-day tribes, people were living integrated within the system in that they were not dominant in the way that we are. That the advance of agricultural man controlled other organisms and their environment and so became dominant in limited areas but that he was still a part of the system of organism/environment. That we may look at a modern industrial city from the same ecological viewpoint and trace similar relationships, an input of food,

air and raw materials, and an output of polluted air, sewage, etc. The critical factor is rate. The input demands are so high, the output so enormous, that we have the food shortage and pollution problems that so concern us nowadays. The system cannot recycle at the rate which is required.

The next step in our understanding of the problem on the world scale is the study of populations. Some understanding of the reaction of natural population to food supply and environment would lead to a study of the human population explosion and its causes and consequences.

With all his power and technological skill, man is still a dependent organism in an ecosystem. He is still dependent as a consumer on the energy captured by primary producers and a major aim has been, and presumably will continue to be, to secure an adequate food supply. So the next main area is to examine the production systems from an ecological viewpoint, looking into man's role, not only of manager of the environment of his domesticated plants and animals but of their growth and their innate constitution and potential. So by working with garden plants and domestic livestock, we might understand some of the basic problems and relate them to the world scale problem of food production.

Wild populations also have a use potential for aesthetic, scientific and leisure purposes as well as potential in constituting part of the gene pool. So apart from ethical considerations we need to understand and provide for this.

Other organisms, no less than ourselves, are dependent on a supply of pure air and water, so that the hydrological cycle and the oxygen and carbon cycles with the current problem of water supply and air and water pollution would need consideration. Since climate affects us all, we might include here some understanding of weather as it affects human activities and the lives of other creatures.

As dwellers on the surface of the earth our lives are affected by the characteristics of land surface. Such consideration might be given to land forms and their relation to underlying rocks as is necessary to reach an understanding of the use to be made of the land. Soils, their development, conservation and use would also be included as would some acquaintance with the implications of the exploitation of mineral resources. Since space is one of man's essential requirements for living, production of essential primary products for work and for leisure, the course might culminate in an examination of the way in which planning decisions are made.

> This approach offers something which most curricula have failed to offer—a humanized science, a subject which puts man at the center and aims to illuminate his impact on the environment and its effect on him. It is science with something of a social conscience, not a series of encounters with hardware but personal involvement with the resources of the earth which develops from the study of the impact of science in increasing the bounty of the earth for its people and which warns us of the folly of reckless exploitation. This, it seems, might just be the sort of scientific discipline which might appeal to the young people who are turning away from traditional science because of its cold detachment from the people and problems of the day.

World Food Supplies

A final step in this series of broadening views of studies based on agriculture might be to examine the problems of feeding a hungry world. This is a matter of supreme importance--perhaps the most critical facing the whole of humanity—whether viewed from a humanitarian viewpoint of the sufferings of 500 million people (perhaps many more) or from the more materialistic viewpoint of the threat to world peace that must eventually be posed by the gross inequities in the distribution of the basic necessities of life. Such a study offers an approach to science through its impact on human affairs and an approach to ecology more closely allied to everyday experience than is usually the case. This study of the acquisition of the basic necessity for life—food—should be part of a liberal education, particularly in view of the facts that the invention of agriculture made possible the development of a settled civilization and that throughout the ages agriculture has stimulated scientific and technological advance. Such study is broadly interdisciplinary, involving the humanities as well as the natural and social sciences. Furthermore, the farmers of this country play a critical part in feeding mankind since they produce the bulk of the grain that enters the international world.

A survey of the problem of feeding an ever-increasing world population might include the following topics:

1. The Origins of Agriculture. Centers of domestication of major crops and livestock; the impact of food production on population and social organization.

2. The Dimensions of World Hunger. Undernutrition and malnutrition—basic nutrition; nutritional needs of the individual; the history of famine; underemployment and poverty in less developed countries as factors; responsibilities of the developed nations.

3. The Balance between Population and Food Supplies. Exponential growth of population and increasing expectations.

4. The Ecology of Food Production. (a) Energetics of food production: crop efficiency; food chain efficiency; ecological versus economic efficiency; outputs in terms of calories per acre; the energy balance between inputs and outputs; subsistence farming and energy-subsidized agriculture; the ecological inefficiency of meat production; vegetarianism; the energy demands of the total food system—production, storage, transport, processing, packaging, marketing; home energy consumption in storage and cooking. (b) Climatic factors and climate change: the Dust Bowl; climate modification; artificial climates—greenhouses, animal production units such as battery laying houses. (c) Soil conservation and land utilization. (d) Biotic factors: pests, diseases, and weeds as competitors with man; beneficial organisms and integrated control; the problems inherent in chemical control.

5. Preserving and Utilizing the Gene Pool of Domesticated and Wild Species.

6. Some Major Problems. Possible climatic change; water

shortage; pest and disease; soil erosion, desertification and urban use of land; pollution; energy shortages; the impact on the land of fuel shortage in less developed countries.

7. Prospects for Increasing Production. Breeding better crops and farm animals; improved management techniques; improved control of pests, diseases, and weeds; greater control of soil and climatic factors, cloud seedings, protected cultivation, hydroponics; technical and financial aid to LDE's; the Green Revolution.

8. New Food Resources. For example, meat-analogous, single-cell protein.

9. The Resources of the Ocean. Securing optimum sustainable yields; over-fishing; progression from hunter/gatherer to marine agricultural modes of using the ocean's productive potential.

10. Food Quality. Food additives and pesticide residues; quality versus quantity in production; legislation.

11. International Organizations and Their Work. United Nations, FAO, WHO; international agricultural research organizations.

## The Energy Crisis

We are all becoming, or ought to become, "energy conscious," aware of our own dependence on many different energy sources. We know that some of those sources are well on the way to being exhausted and that we have to reduce energy consumption and look for alternative sources. Part of the solution must lie in education. The study of the present energy crisis, therefore, meets the criterion mentioned earlier: science teaching must take into account the impact of science on human affairs. Probably no topic illustrates this better than a study of the energy situation. In

support of this assertion, it can be said of energy that:

1. It illustrates the social impact and social responsibility of science.

2. It is clearly relevant to students' lives and is a matter of current concern.

3. It is an integrating factor in the sciences, involving biological, physical, and earth sciences.

4. Beyond this, it is an integrating factor between natural science and social science and humanities, since an understanding of the situation involves matters of politics, economics, mathematics, law, history, geography, ethics, agriculture, and home economics as well as the natural sciences. It could be the subject for interdisciplinary studies in the broadest sense. It involves study of some of the basic principles of physics, biology, and chemistry.

5. When it comes to matters such as wind power, solar energy, and biomass energy, there are opportunities to link science and technology; to work with an accessible "intermediate technology"; to get science out of the laboratory into real-world situations; to investigate local conditions to discover local energy use patterns, sources of energy, and the possibility of local development of alternative energy sources; to involve students in real design problems, i.e., using scientific knowledge and simple technology to produce effective solutions to such problems as collecting solar energy and also to involve them with the aesthetics of the situation: equipment must not only be effective and well constructed but must be satisfactory in appearance; to directly benefit the community by providing a local information service; and, conceivably, to establish some small-scale local industry.

A course about "energy" might embrace the following topics:

1. A study of personal energy use, including a quantitative assessment of energy used in the home for heating, hot water, cooking, lighting, entertainment, cleaning, food storage, etc.; of energy consumed in food systems including energy used to produce food, as well as to store, transport, process, package, and market it; of energy used in travel; of energy used for services such as schools, police, defense, etc.; and of energy used in producing goods such as tractors and newspapers. It would also include a comparison of per capita use of energy in this and other countries.

2. The energy flow in biological systems, including natural and man-managed ecosystems; production of food energy; energy use on the farm; and ratio of calories in to calories out in various production enterprises.

3. The history of energy consumption in the country; the exponential growth of energy use.

4. The depletion of fossil fuels and the need for alternatives.

5. Conservation measures, such as home insulation.

6. Alternative energy sources—wind, geothermal, solar, biomass, etc.

7. Nuclear power, its prospects and the hazards involved.

8. The laws of thermodynamics: heat transfer, the forms of energy, their measurement, and the conversion of energy from one form to another.

One would hope that such a course would make students aware of patterns of energy use on personal, local, national, and world levels, of

the present and possible sources of supply and their limitations, of the possibilities for conservation, and of the probable changes in lifestyle that the current energy shortage is likely to bring about. Parallel with this, one would expect them to understand the energy relations in biological systems and the place of our own food system in the overall energy pattern. Above all, they should develop a commitment to using energy more carefully in their own lives and to helping to improve the energy situation in their own community.

The demand for greater freedom from imported oil will continue to have profound effects on rural areas. Alternatives are constantly being sought—mining for fossil or nuclear fuel, dams for hydroelectric power, windmill systems, arrays of solar collectors, and the production of biomass energy in the form of wood, alcohol, or methane.

Solar Energy

We are told that, alongside conservation measures, solar energy promises the best hope of a continuing alternative energy source for the future. Therefore, it deserves special consideration as part of an energy course such as that suggested in the previous section or, perhaps better, as an additional interdisciplinary course. It would be a science course that would tackle "real world" problems relating to the needs of the local community. Students would experiment with designing active and passive systems which were "custom designed" to meet the needs of local people and institutions. Thus, they would be combining an understanding of some of the basic principles with the application of such principles in a manageable technology. Because the technology involved is one that is up to date and constantly developing, there is an opportunity for students to make

their own original contribution. The technology involved is relatively simple, and a minimum of apparatus and equipment is needed. The course also allows a complex-to-simple teaching mode. For example, one could start with a simple flat-place solar collector and use it to discover the various parameters involved: the area needed to achieve certain results, the orientation required, insulation, nature of the light-transmission surface, color of absorptive layer, effectiveness of hot-air versus hot-water systems, and so on.

In designing even a simple collector from scratch, a number of disciplines are involved: basic physics, shop crafts, astronomy, meteorology, aesthetics, mathematics, economics, and homecrafts.

This development of home solar energy use is nationally important, but it is particularly suitable for adoption in rural communities. It offers the prospect of valuable community service and might even be made into a commercially viable small business, requiring minimum equipment and work space and small capital outlay.

While the use of solar energy collection by both active and passive systems would be the core of the activity, the subject invites study of the broader perspectives of the sun's role in supplying energy to the earth. Consequently, most of our energy resources—human food, "gasohol," methane generation, wood, the fossil fuels, water and wind power—would be incorporated. Indeed, with this as a basic theme, one could teach all that is needed in high school physical, earth, and biological sciences.

## ORGANIZATION OF THE RURAL SCIENCE PROGRAM

### Team Teaching

A science program that takes into account the current problems

facing society will of necessity bring together the social sciences and the natural sciences, while almost inevitably writing and mathematics will be involved. Therefore, some sort of collaborative teaching is almost a necessity. This term seems preferable to "team teaching" because the latter has come to mean one particular form of shared teaching, while there are many ways in which two or more teachers may work together. They might just be present with the class as resource people when project work is under way, they might be in charge of different groups when a local survey is being carried out, or they might lead opposite sides in a debate. Whatever its form, shared teaching can provide an exciting change of style for students and a satisfying and instructive interchange of knowledge and experience for teachers. It certainly provides broader perspectives. The small faculty and student numbers in most rural schools make collaborative teaching relatively easy to organize.

## Scheduling

One great advantage that the small rural school has is the potential flexibility of scheduling, both in class time and teacher assignments. Blocking sections of time to make a half day or even a whole day regularly available for engaging in away-from-school or particularly time-consuming activities makes a more efficient use of time possible and relieves the tedium of doing the same thing at the same time every day. It also facilitates arrangements for collaborative teaching and mixed-grade classes. When environmental studies was first introduced, one group of schools solved the problem of fitting this multidisciplinary subject into the schedule by combining classes for an afternoon and making several staff members available. In spite of the logistical problems of dealing with relatively large groups of students, it worked well.

There is no real reason why biology should be taught in the ninth grade, chemistry in the tenth, and physics in the eleventh. Indeed, there are many good arguments against such an arbitrary splitting of science learning. Nor is there any better reason for splitting young learners into arbitrary age groups—with both young children and university-level students, mixed-age groups are commonplace. To combine two or more grades may sometimes be the best expedient when numbers are too small to justify certain courses otherwise. Perhaps a little extra tact may be needed to satisfy the egos of seniors who must mix with their juniors, but it should cause no insuperable difficulties!

Initial Teacher Training

The job of teaching science in the small rural high school may be very different from that in the large urban school, where specialists in several scientific disciplines are involved. What is needed in the rural school is not the highly specialized physicist, chemist or biologist, or earth scientist, but the teacher who has a sound enough grasp of the basics of all of these to understand their relationships, to interpret the rural environment, and to guide investigation at the level necessary to satisfy the needs of high school students. For this purpose, a good grounding in biology and basic physical science is necessary with some understanding of the earth sciences and perhaps basic chemistry. An environmental science program might incorporate all the elements needed.

Arts and sciences colleges are not generally concerned specifically with the needs of teachers, and colleges of education expect their recruits to have acquired the factual knowledge in their subjects before starting on their methods courses, so it is nobody's business to provide

science teachers with the appropriate range of knowledge to suit their teaching needs. However, most basic science courses are aimed at getting over the ground as quickly as possible while advanced courses are provided for people who are preparing to be professional scientists, engineers, etc.

What is needed for rural teachers, perhaps even for all teachers, is the opportunity to study the basics of science in more detail and to learn to appreciate the many links between the sciences so they can bring two or three scientific disciplines to bear on a topic. The title of the Master of Basic Science Program at the University of Colorado suggests the appropriate sort of program, though it is needed at first-degree level.

There is a need for more programs of this kind specifically designed to fit the needs of teachers who are preparing to teach science in rural schools. If science teachers in rural schools were specifically trained for those situations and if they were teaching courses especially devised to suit the conditions of those areas, they might feel more able to take pride in their work, more inclined to regard their courses as something special, different from the usual but in no way inferior. If this were the case, they might be less inclined to "move up" to larger urban schools. Then, in this one area at least, schools might achieve more stability in their teaching staffs.

Continuing Support for Teachers

Creating new courses and modifying old ones is a step towards improved science teaching, but simply to offer new courses to teachers, however appropriate they may be, is only a step. There must be continuing support for teachers to enable them to modify, adapt, and improve their teaching in the light of experience and in reaction to changing needs and circumstances.

Neither the resources of small rural school districts nor the number of teachers involved is likely to enable that "critical mass" of people to come together to initiate and continue a program of curriculum improvement. Some arrangements need to be made, perhaps through the Regional Educational Laboratory System or intermediate service units, to enable groups of teachers with converging interests to be brought together and given outside support in their efforts. These might encompass the following programs:

1. Inservice courses for teachers. These constitute the accepted method for helping teachers to update and upgrade their teaching. The provisions for helping teachers create new programs, mentioned in the previous section, apply here, especially that of bringing courses to teachers wherever possible instead of taking teachers to courses. These would become working parties where outside experts would work with teachers to improve teaching in the sciences, rather than act as instructors telling them what to do.

2. Teachers' centers and science teaching resource centers. The value of teachers' centers as places where teachers can find sustained support and encouragement has gained greater recognition in official circles, partly through federal grants to new teachers' centers, niggardly though the provisioning be. More specifically, it has been recommended that science teaching resource centers be set up in selected locations. However desirable these developments, it seems unlikely that the scattered teacher population and limited finances in rural areas will make them available to most rural teachers, especially as the essence of a teachers' center is its availability—it should be in a place where teachers can conveniently and more or less regularly "drop in." However, if there is an empty

classroom available, it might be possible to use it as a science teaching center, voluntarily staffed by teachers or perhaps by members of a local science teachers' association, and supplied on a very modest scale.

3. Advisors. Good courses provide a tremendous stimulation for teachers, but they are at best highlights in the continuum of teaching: they come and are all too soon gone. How much of the knowledge and enthusiasm from the courses ever gets translated into improvement of classroom teaching? Day-to-day duties and frustrations soon overtake the teacher so that stimulation and enthusiasm for new things soon vanish unless some continuing encouragement can be found. What is so successful elsewhere and is so badly needed here is a sound advisory service, so that the teacher will be helped in his own classroom to put new ideas into practice.

The people needed are not curriculum supervisors, who are part administrator, whose influence rests on authority, and who are tainted with "head office," but people with successful teaching experience and with wide knowledge of their subjects, who will be able to spend time visiting schools and helping and encouraging teachers. Unfortunately, school district finances are not likely to be able to support such a luxury; yet, if one looks at the education system as a whole and the enormous sums of money available in grants from federal, state, and private foundation sources, the money is there. What is missing is the conviction that, given sufficient support, teachers can improve the educational system from the ground up, instead of being recipients of attempts to change it from above.

In Britain, where there is a widespread and well-established service, some school districts where money was scarce were able to persuade the public to provide "advisory teachers" when the same people, if

called "advisors" or "organizers," would have been looked on as an unnecessary layer of administration.

A group of school districts with, say, 20 small high schools, could employ a science advisory teacher to spend one day a month in each school—little enough but at least some continuing support for the staff. If there were, say, 30 science staff in all, the additional cost in salaries would mean only a 3–4% increase in the salary bill for this part of the curriculum; and if the total staff were 200, then the addition would be only ½%—not very much compared with 12% inflation.

4. Teachers' associations. Lacking the support of advisors, teachers usually say they get most help from other teachers, but the rural science specialist may have very infrequent chances to meet other teachers with like interests. Teachers' groups or associations meeting, say, once a month in one or another of the schools whose staff are involved, perhaps moving around the circuit, can be of tremendous help here. In some places they have been highly successful in bringing teachers of like interests together to improve their own professional competence, to advance the teaching of their subjects, and to press the case for improved facilities.

A critical matter seems to be the size of the group: if it is too small, it will probably not be viable. On the other hand, if in order to bring in a large membership it covers too large a territory, then again members will not want to travel long distances to attend meetings. In Britain, rural science teachers formed county associations meeting locally every month or two. These were then federated into a national association which held annual conferences and which became very influential in advancing the cause of rural science teaching. In geographical scale, a state federation in this country might be the equivalent of the national association

in Britain. Given very modest financial support for travelling and perhaps the preparation and dissemination of a newsletter, teachers' associations can, to a large extent, replace teachers' centers and advisory services.

Strategy

The initiative and financial support for any program of rural curriculum improvement on the lines suggested will almost certainly have to come from outside the individual school system. Regional Educational Laboratories and intermediate service agencies are the most likely candidates, along with, perhaps, schools of education and local colleges. But such support could even be some form of outreach from a teachers' center or a science resource center, although it is unlikely that most of these would have the resources or inclination to move away from their base.

The organization taking the initiative would then need to approach school districts to identify teachers who are interested in change. It would then be necessary to bring those teachers and school districts within a given geographical area together to form some loose, mutually supportive, educational network.

Presumably most of the expert help would come from colleges and universities, particularly from those faculty members who are trying to improve teaching in their own institution—departments of general education and of innovative education, interdisciplinary studies, integrated studies, and the like. Schools of education, county extension agents, soil services, forest services, and other specialists and knowledgeable community members might lend their expertise, though probably at a later stage.

Once the potential participants have been identified, a course—or preferably a conference to avoid any suggestion that the teachers were to be

coerced—could be arranged. Teachers should feel that it is their show, that they are there because they want to improve, not because someone else wants them to. Courses, conferences, and meetings can then be arranged because the teachers want them, not because someone from outside thinks they should have them.

We all feel more secure in our own territory, and at every stage teachers need to be able to meet on their own ground. If they have to go to the local university or college or state office, there is always the feeling of unreality, of having to deal with people who don't really know what the local circumstances are and what problems have to be faced and who probably haven't taught in school for a long time, if ever. Once new programs are underway, then continued support is needed; and again teachers need it in their schools, not in some distant center.

It would be essential from the earliest days of the venture to see that the school board and local community members were informed about what was going on. They would want to know that their children were not being offered some inferior substitute for the standard variety of courses, a watered-down version of what is offered in the big city schools. University professors visiting the community can be very reassuring in this. Community members whose knowledge and interests qualify them to do so might be very useful participants at some stage of the process of curriculum improvement, and they might do a great deal to further community acceptance of change.

There would be certain expenses: release time for teachers to attend meetings at some central location, cost of travel, consultants' fees and expenses, as well as a modest amount for new materials and equipment

and office operation and for continuing support costs to enable the school districts and teachers involved to maintain their collaboration. Regional Educational Laboratories and grant-awarding bodies such as the National Science Foundation might help here.

Rural school districts do not have the resources to support teachers' centers, advisors, etc., but consortia of small school districts might arrange jointly to provide a modest teachers' center and invite people in to provide refresher courses or to share the services of a science advisor. There would probably be some suspicion that this was a form of "creeping consolidation," but, on the contrary, it would prove that local autonomy and the economics of scale were not inconsistent.

## ABOUT THE AUTHOR

Ron Colton brings together a background of rural life, science, and good teaching. A major portion of his experience has been in England, where he was Head of Science and Rural Studies for Wrotham County Secondary School and Principal Lecturer in Environmental Science and Head of the Science Department, Northumberland College of Education, University of Newcastle, Institute of Education.

Since coming to the United States, Mr. Colton has served as Associate Director, Mountain View Center for Environmental Education, University of Colorado. This Center works with classroom teachers in the use of the environment of the local school setting in instruction. Mr. Colton has worked with teachers in settings as diverse as Boulder, Colorado; Douglas, Wyoming; and the Hopi Reservation. He is the co-author of the book The Teaching of Rural Studies, Edward Arnold LTD., London.

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